ELECTRICAL CONNECTOR APPARATUS AND METHOD

Background of the Invention

The present invention relates to electrical connectors. In specific embodiments the invention pertains to an electrical connector for coupling to an insulated single conductor electrical cable or to a coaxial cable.

Typically, in installing single conductor cable including a central conductor with an outer insulation, the end of the wire is stripped of insulation and the bare wire is inserted into a connector where it is soldered, clamped or otherwise attached to the connector. Similarly, with coaxial cables which include a central conductor enclosed in an inner concentric insulation covered by a concentric conductive sheath and encased in an outer insulation, the common practice is to strip the outer insulation to expose the conductive sheath.

It is an object of the present invention to provide an improved electrical connector and method for mechanically coupling and for electrically coupling an insulated electrical cable to an electrical connector without the need for stripping the insulation from the cable.

Brief Summary of the Invention

The subject invention pertains to an electrical connector having a housing with a central bore for receiving an electrical cable, one or more clamping members having inwardly pointed ends in the bore and a closure member for insertion into the bore for closing the bore and for driving the pointed ends of the clamping members into mechanical connection with the electrical cable.

In application to a single conductor cable, the pointed ends of the clamping members may make mechanical connection to the cable and alternatively make electrical connection between the housing and the conductor of the cable. In application to a coaxial cable the pointed ends of the clamping members may make mechanical connection to the cable and electrical connection between the housing and the concentric sheath of the cable.

The closure member or end cap is moveable longitudinally into the bore of the housing and engages, at its outer periphery, the inner periphery of the bore. In its longitudinal movement into the bore it engages the ends of the clamping members to drive the ends radially into the electrical cable. The longitudinal movement of the end cap may be by way of threaded rational movement or by the application of a longitudinally directed force.

The electrical connector of the invention may be provided with a center pin or prong for making an electrical connection beyond the connector, and may be provided with a mounting therefor, which extends the prong into the bore of the housing to make electrical contact with the central conductor of the cable. Alternatively, the housing may include a central guide and aperture which would permit the central conductor of a cable stripped of its insulation to extend appositely beyond the bore of the housing for making electrical connection beyond the connector.

Brief Description of the Drawings

Figure 1A shows an embodiment of the subject connector for use with a single conductor insulated electrical conductor.

Figure 1B shows a specific embodiment of an electrical connector in accordance with the subject invention for use with a coaxial cable type insulated electrical conductor.

Figure 2 shows a specific embodiment of an electrical connector in accordance with the subject invention, incorporating an endcap having one or more protrusions.

Figure 3A shows an embodiment of the subject electrical connector, which incorporates a beveled ring and a compression ring.

Figure 3B shows the electrical connector of Figure 3A after insertion of the cap into the housing.

Figure 3C shows the electrical connector of Figure 3A incorporating a key and groove to prevent the beveled ring from rotating with respect to the housing.

Figure 4 shows an embodiment of the subject invention where clamping arms extend toward the end of the insulated electrical conductor.

Figure 5 shows an embodiment of the subject connector which utilizes the center conductor of the coaxial cable rather than a pin.

Figure 6 shows an embodiment of the subject connector which utilizes the center conductor of the coaxial cable rather than a pin and the inner insulation of the coaxial cable to electrical isolate the center conductor of the coaxial cable from the housing.

Figure 7 shows an end view of an electrically conductive clamp in accordance with the subject invention having eight clamping arms which have been manipulated into the clamped position.

Figure 8 shows a specific embodiment of an individual clamping arm broken away from the housing.

Figure 9A shows a side view of a conductive pin in accordance with the subject invention, incorporating a hollow portion having a single slit.

Figure 9B shows an end cross-sectional view of the hollow portion of the pin shown in Figure 9A.

Figure 10A shows a side view of a conductive pin in accordance with the subject invention, incorporating a hollow portion having two slits.

Figure 10B shows an end cross-sectional view of the hollow portion of the pin shown in Figure 10A.

Detailed Disclosure of the Invention

Referring to Figure 1, an electrical connector **100** in accordance with the subject invention is shown for use with a coaxial cable **11** having a single solid or braided conductor **12**, a concentric insulation layer **13**, a conductive sheath **14** and an outer insulation **15.** Connector **100** has a housing **25** made up of a rotatable terminal section **25A**, an interconnecting section **25B** and a housing section **25C**, which are in electrical contact with each other. Housing sections **25A**, **25B**, and **25C** can be generally cylindrical in shape and designed such that section **25B** holds section **25A** in place and makes an interference fit with

section **25C**. Section **25A** can rotate relative to sections **25B** and **25C** about the axis of the connector, which allows section **25A** to be threaded onto a counterpart connector. Alternatively, section **25A** can be fixed such that all three sections **25A**, **25B**, and **25C** form a single integral housing **25.** In this case, the section **25A** can slide onto counterpart connectors rather than being threaded.

Housing section **25C** can have a central bore **105** with an open end **107**. A conductive clamp **112** can be disposed within the bore. Conductive clamp **112** can be generally cylindrical in shape and include a collar portion **114** and one or more clamping arms **113** extending from collar portion **114**. Preferably, the outer periphery of collar portion **114** is approximately the dimension of the inner periphery of bore **105**. Collar portion **114** can support clamping arm(s) **113** in longitudinal extension toward open end **107** of bore **105.** Clamping arm **113** can have a beveled edge **115** directed radially inward and which can be contacted to urge tip **133** radially inward. The clamping arm(s) **113** can make electrically conductive contact with the housing section **25C**, for example, through collar **114**. Alternatively clamping arm(s) **113** can be made integral with electrically conductive **25C** and/or **25B**.

The opposite end of the bore **105** can be closed by a plug **218** of electrical insulating material that can be secured in the interconnecting section **25B** by a pressure fit or adhesive or other means, and has in it a central aperture **219** which communicates between the bore **105** and the open space of terminal section **25A**. In the configuration of Figure 1, an electrically conductive pin **202** can be secured in the central aperture **219** with its head portion **202A** projecting into bore **105** and its terminal portion **202B** projecting into the open space of section **25A**. The head portion **202A** may be of a split pin type as illustrated but may also be of the solid pin type such as the terminal portion **202B** as electrical connection conditions may dictate.

A closure member or end cap **200** of strong and resilient material such as plastic, nylon, rubber, brass or metal can be disposed in the open end **107** of the housing section **25C**. Cap **200** is preferably of an internal diameter to receive a cable for connection, shown to be a coaxial cable **11** in Figure 1.

Figure 1 shows cap **200** positioned just inside housing **25** where protrusion **204** on cap **200** resides in indentation **206** of housing section **25C**. The interaction of protrusion **204** and indentation **206** can hold cap **200** in position, allowing the connector to be held as a single unit prior to attachment to the end of a coaxial cable.

Accordingly, with the end of a coaxial conductor **11** inserted through cap **200** and into housing section **25**, the cable can then be pushed further into housing **25** where the hollow pin **202** penetrates the end of the coaxial cable between the center conductor **12** of the cable and insulation layer **13**, making electrical contact between the center conductor **12** and pin **202**. Cap **200** can include a beveled edge **201** the end of the cap which enters open end **107** of the housing. Beveled edge **201** can be complimentary to beveled edge **115** of the clamping arm **3**.

Once the electrical contact has been made between pin **202** and the center conductor of the coaxial cable, cap **200** can be pushed further into housing section **25C**. Pushing cap **200** into housing section **25C** can, by action of beveled edge **201** of cap **200** operating on beveled edge **115** of clamping arm(s) **113**, push clamping arm(s) **113** toward the coaxial cable causing tips **133** of clamping arms **113** to penetrate and pass through outer insulation layer **15** of coaxial cable **11** and make electrical contact with outer conductor **14** of coaxial cable **11**. As cap **200** is pushed further into housing section **25C**, protrusion **204** interacts with indentation **208** and/or protrusion **210** interacts with indentation **206.** The interaction of protrusion **210** and indentation **206** and/or protrusion **204** and indentation **208** can act to hold cap **20** securely in place inside housing **25**. Alternatively, if desired, cap **200** can be separate from the housing and slipped onto the end of the coaxial cable prior to the end of coaxial cable being inserted into housing section **25C**. Cap **200** can then be slid down the coaxial cable and pushed into housing section **25C**

Thus by cooperative action between the housing section **25**, the end cap **200** and the clamping arm(s) **113**, the cable **11** is securely attached mechanically to the connector **100** and in addition the clamping arm(s) **113** complete electrical contact between the outer conductor **14** of the cable and the housing **25** of the connector **100.** Additionally, with respect to the embodiment shown in Figure 1, electrical contact is made with the center conductor **12** and

pin **202** of connector **100** which is electrically insulated from the electrical connection made between the conductor **14** and the housing **25** of connector **100.**

Preferably, the subject connector is designed to resist the entry of moisture. For example, it is preferred to prevent moisture at the point of penetration of clamping arms **113** into the coaxial cable and at the end of the coaxial cable. Accordingly, O-ring seals **212, 214** and/or **216** can be utilized to reduce or prevent moisture at these sensitive areas.

Preferably, the tolerances of the inner diameter of housing section **25C**, the thickness of cap **200**, and the dimensions of the coaxial cable and its outer insulation are such that the penetration depth of the tip of the clamping arm **113** into the coaxial cable can be controlled. Such control of the penetration depth can be used to optimize the electrical contact between the clamping arms **113** and the housing, the impact the clamping arms have on the structure of the coaxial cable, and the friction created between the cap **200** and the coaxial cable.

Clamping arms **113** instead of being located in section **25C** prior to the insertion of the end of the insulated conductor into section **25C**, can be attached to the end of a coaxial cable prior to insertion of the end of the coaxial cable into housing section **25C**. For example, a user can align collar **114** and clamping arms **113** on the end of a coaxial cable and then press the tips **133** of clamping arms **113** into the side of the coaxial cable by hand, with pliers, or with some other mechanism. The end of the coaxial cable can then be inserted into housing section **25C** and cap **200** inserted into housing section **25C**. In this embodiment, cap **200** need not necessarily press the clamping arms **113** into the coaxial cable, but preferably reaches far enough into housing section **25C** to hold clamping arms in place with respect to the coaxial cable. In this case, the front of cap **200** need not have a beveled front edge.

In a further alternative embodiment, a tool might be used to push tips **133** of clamping arms **113** into the outer insulation of the coaxial cable prior to the insertion of cap **200** into housing section **25C**. Such a tool can slide into housing **25C** and urge clamping arms **113** into the side of the insulated electrical conductor. In this embodiment, the beveled edge of cap **200** can have a different shape, as the cap would not necessarily be responsible

for pushing the tips of clamping arm **113** into the coaxial. The cap **200** can still be useful for holding the clamping arms in position.

Figure 2 shows a variation of the connector **100** of Figure 1, wherein the conductive pin **202** is shown to have a head portion **202A** which is of the solid pin type rather than a split pin type and wherein the cap **200** is modified to include one or more slots **221** in the side wall and an inner circumferential ridge **220** spaced intermediate the ends of the slot **221.** The head portion **202A** is illustrated as a solid pin type adapted for piercing either the stranded electrical conductor **21** of a single conductor cable **20** as shown or a stranded center conductor of a coaxial cable. Head portion **202A** can also make electrical contact with a solid center conductor of a coaxial cable. The purpose of the slot **221** and ridge **220** is to provide a stress relief area around the circumference of the end cap **200.** Accordingly, when the cable **20** is in place in the connector engaging the conductive pin **202** and the cap **200** has been pushed in to seat the conductive arms **113** in the outer wall **22** of the cable, further longitudinal pressure on the end of the cap causes the side wall of the cap **200** to move inwardly along the ridge **220** thereby applying clamping pressure to outer wall **22** of the cable **20** to further mechanically secure the cable in place in the connector. The use of the slotted end cap with a single conductor cable is merely illustrative and may be used advantageously with coaxial cables.

Figure 3A is an expanded view and Figure 3B is an assembled view of another embodiment of the invention of Figure 1 which includes a double beveled ring **222** and a compression fitting ring **224** to provide additional gripping action on a cable inserted in the connector. Beveled ring **222** is positioned in the housing section **25C** such that a first beveled edge contact the beveled edge **115** of the clamping arms **113**. Compression ring **224** can then be placed into housing section **25C** such that compression ring **224** contacts the other edge of the beveled ring **222**. When cap **200** is forced into housing section **25C** it pushes compression ring **224** into beveled ring **222** which in turn forces clamping arms **113** radially inward to engage a cable inserted in the housing section. The ring **222** comes to rest and the compression ring **222,** compressed between cap **200** and beveled ring **222** is forced radially inward against the coaxial cable to further grip the coaxial cable and hold it in place.

Figure 3C is a variation of the embodiment of Figures 3A and 3B in which the end cap **200** and the housing section **25C** are threaded for rotational longitudinal movement instead of sliding longitudinal movement. In this embodiment the beveled ring **222A** is keyed with a discrete protrusion **222B** which fits into a longitudinal slot **226** in the housing **25C** to prevent rotation of the ring against the surface **115** of the clamping arm(s) **113**. In other respects the embodiment operates in the same manner as that of Figures 3A and 3B.

In the embodiment of Figure 4, the position of the conductive clamp **112** has been reversed from that shown in Figure 1 so that the clamping arms face inwardly in the bore **105**. Further, the interior of the housing section **25C** has been provided with a ramp **116** against which the beveled edge **115** of the camping arm **113** rides. The interior end of the cap **200** has been made blunt in order to engage the conductive clamp **112**. Accordingly, with a cable positioned in the connector, longitudinal movement of the cap **200** into the bore **105** forces the clamping arms **113** to ride up the ramp **116** and radially inward so that the tips **133** pierce into the cable.

Figure 5 shows an embodiment of the invention of Figure 1 wherein the center pin **202** has been removed and the cable **11** has been cut back to expose a length of the center conductor **12** adequate for projecting through the insulator plug **218** into the open portion of the terminal housing **25A**. Further, Figure 5 shows an embodiment of the invention of Figure 1 wherein the center pin **202** and the insulator plug **218** have been removed and the cable **11** has been cut back to expose a length of the center conductor **12** adequate for projecting into the open portion of the terminal housing **25A** and the insulation layer **15** and conductive sheath **14** have been cut back to expose the insulation layer **13** of sufficient length to nest in the interconnecting section **25B** and to electrically isolate the conductor **12** from the housing **25**. In all other respects the configuration of Figures 4 and 5 function in the same manner as described relative to that of Figure 1.

Figure 7 shows an end view of an embodiment having eight clamping arms **113** extending from a collar **114**, as shown in Figure 1, which have been clamped into place. Clamping of arm **113** in order to drive tip **133** into the insulation can be accomplished, for example, with a special tool for reaching into housing **25C** to urge arms **113** toward the

cable, by pushing cap **200** into housing **25C**, or by pressing arms **113** into the insulation by hand, with pliers, or with another tool prior to insertion of the end of the insulated conductor into the housing. Dashed lines **226** and **228** represents the edges of the beveled surface **115** of the clamping arms. Around the outside collar **114** can be seen through the spacings between arms **113**.

The curve of the end **133** can also be selected to optimize the performance of the connector. In Figure 7, the curve of end **133** is selected such that the eight ends form a circular pattern of deepest penetration into the conductive sheath of the coaxial cable. The dotted circle **232** in the center of Figure 6 represents the approximate location of the inner conductor of the coaxial cable. Referring to Figure 8, a single clamping arm **113** broken away from collar **114** is shown. The pointed end **133** of clamping arm **113** can have a variety of shapes, in order to optimize one or more operational characteristics of the electrical connector. In the embodiment shown in Figure 8, pointed end **133** is shaped such that as the clamping arms are manipulated to cause the piercing of the outer insulation, the sides **134** of the clamping arms come into contact with the adjacent clamping arms so as to prevent further penetration of the pointed end **133.**

Referring to Figures 9A, 9B, 10A, and 10B, specific embodiments of a pin **202** which can be utilized with respect to the electrical connectors of the subject invention is shown. For example, either pin shown in Figures 9A and 10A, or variations thereof, can be incorporated with the electrical connectors shown in Figures 1-6. Both Figures 9A and 10A show side views of pins having a hollow portion on one end for receiving an electrical conductor and a solid portion for connecting with and an external apparatus on the other end. Other pin embodiments are possible which, for example, have a solid portion at each end of the pin or have a hollow portion at each end of the pin. In addition, the entire pin can be hollow if desired. Preferably, the hollow portion of each pin can have one or more slits. The number, lengths, and widths, of the slits can vary depending on the application. Figure 9A shows a slit which extends about half the length of the hollow portion of the pin, while Figure 10A shows two slits which extend essentially the entire length of the hollow portion of the pin. Figures 9B and 10B show end views of the hollow portions of the pins shown in

Figures 9A and 10A, respectively. These slits can allow the hollow portion to expand to just the right size to receive an electrical conductor such that a good electrical contact can be made.

The present invention should not be construed as limited to the forms shown which are to be considered illustrative rather than restrictive.